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H2A DA

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GB 1079815

EP A 0114260

(58) Field of search

B3A

H2A

Selected US specifications from IPC sub-class
H02K

(54) Alternator stator with inserted windings

(57) The stator includes a core 2 having a plurality of slots formed in its inner periphery; a stator winding 7 partially inserted in each of said slots of said stator core; and an electrically insulating material inserted between said stator winding and the surface of said stator core opposing said stator winding, wherein said slots formed in said stator core have a substantially rectangular cross-sectional form and the portions of said stator winding to be inserted into said slots also have a substantially rectangular cross-sectional form, with the other portions 7b having a circular cross-sectional form. The rectangular cross-section of the winding portions is achieved before insertion in the slots by a hydraulic presser plate 15. The winding conductor initially may be of hollow cross-section.

FIG. 4

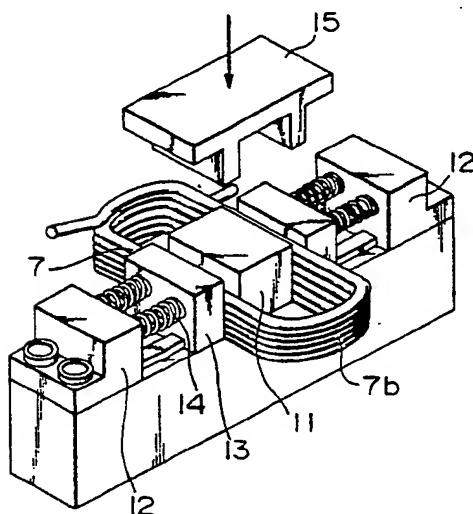
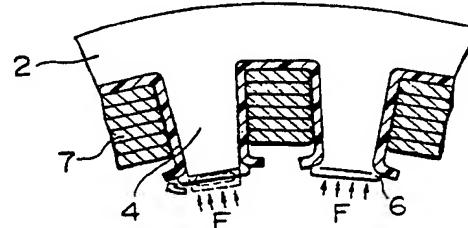


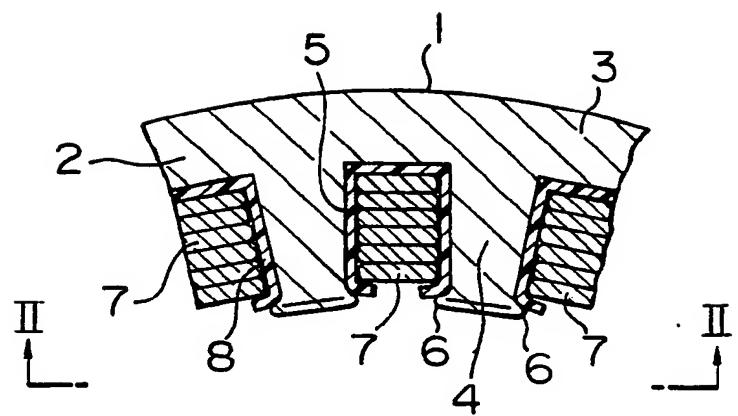
FIG. 7B



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F I G. 1



F I G. 2

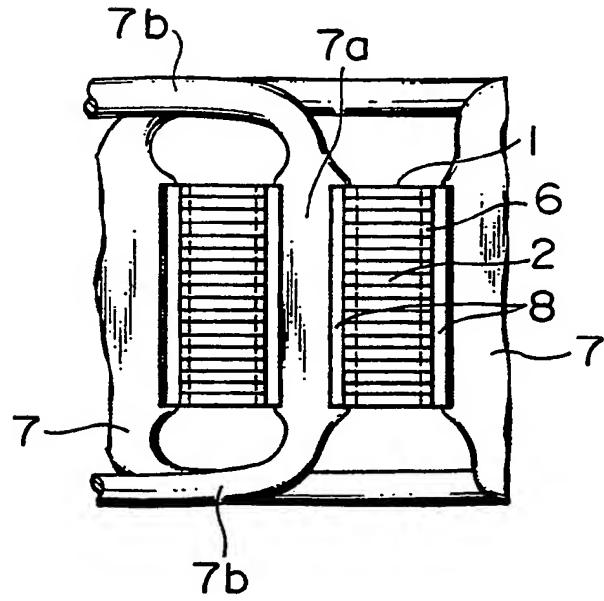


FIG. 3

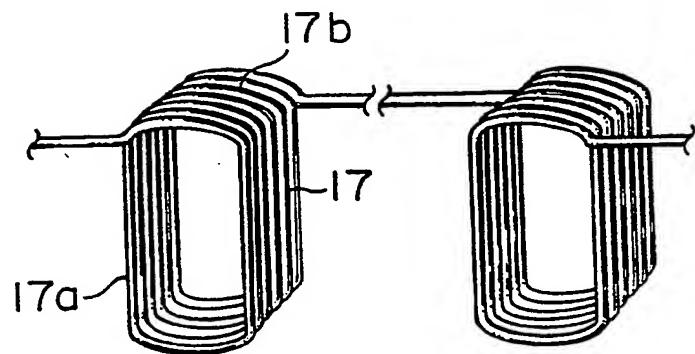
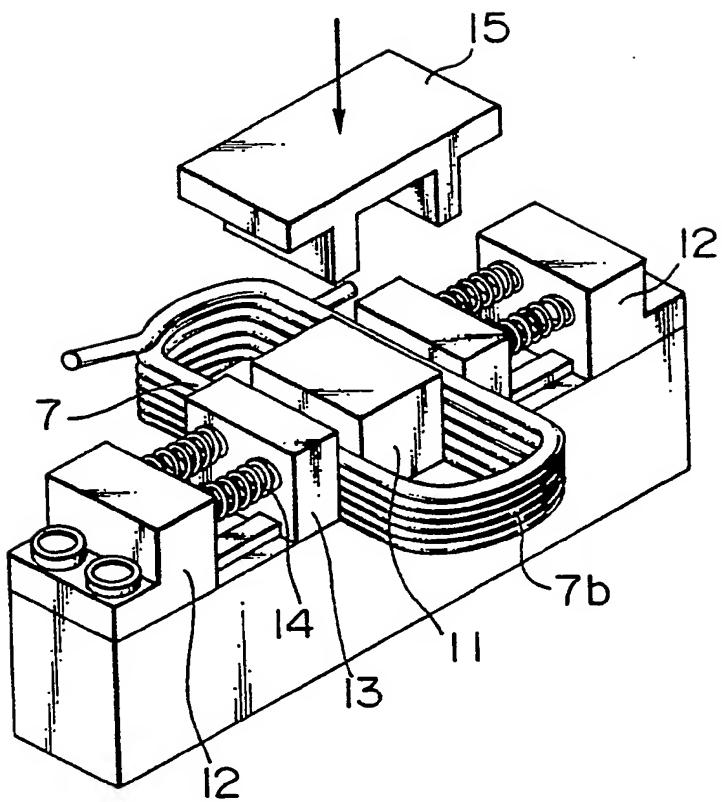


FIG. 4



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FIG. 5

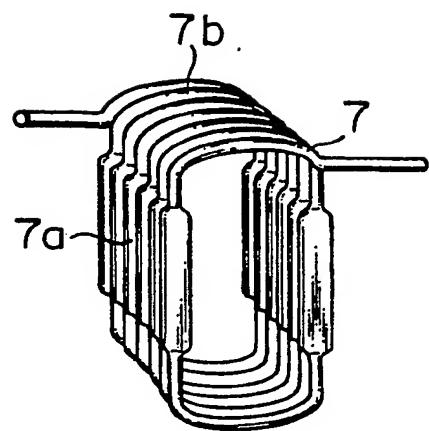
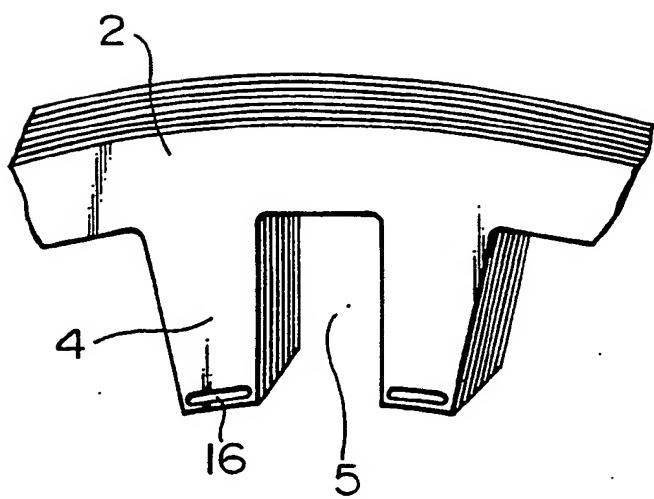


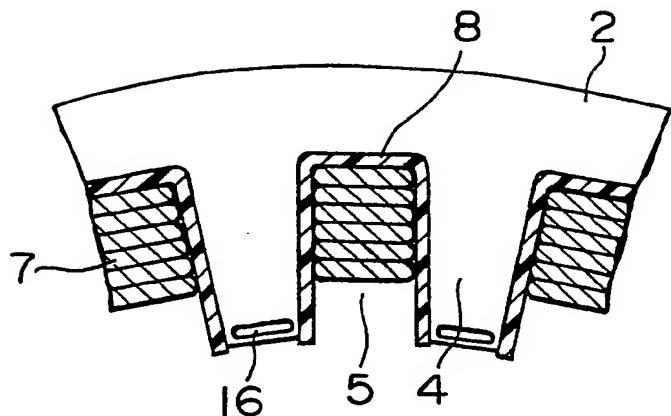
FIG. 6



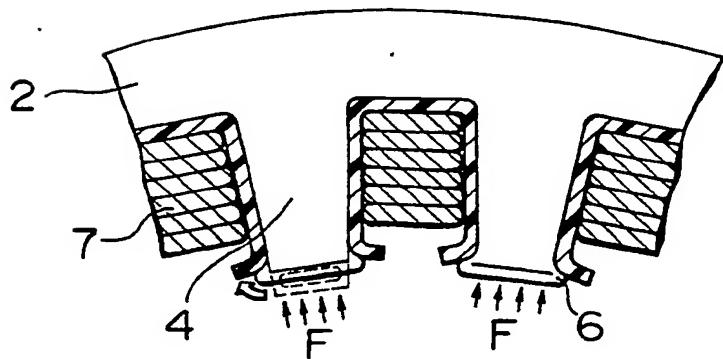
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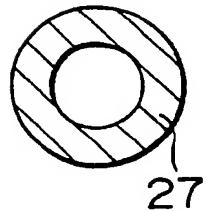
F I G. 7A



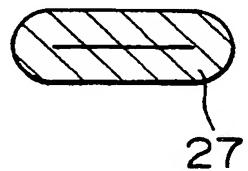
F I G. 7B



F I G. 8A



F I G. 8B



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FIG. 9

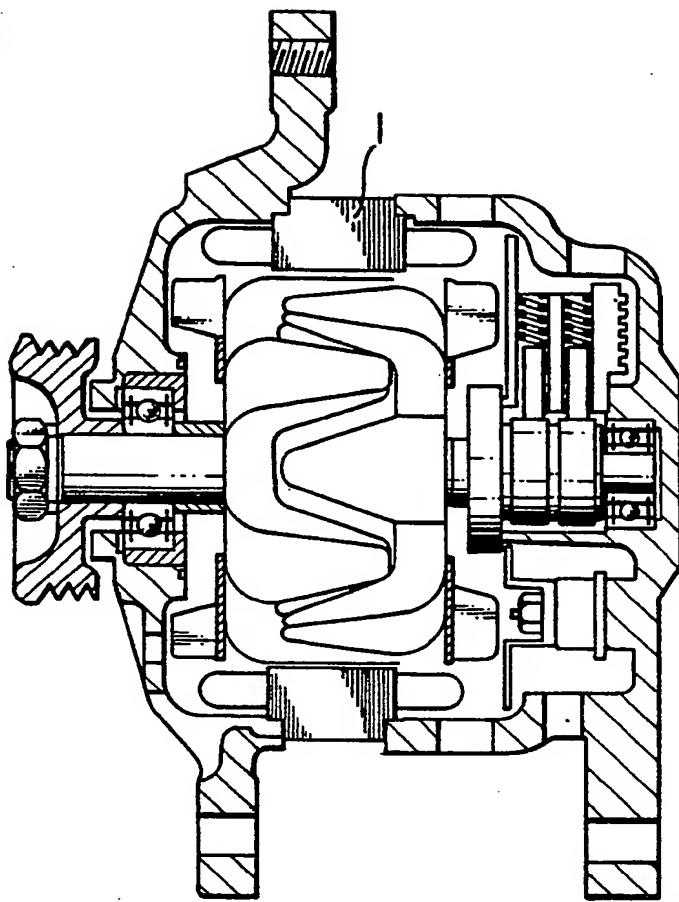
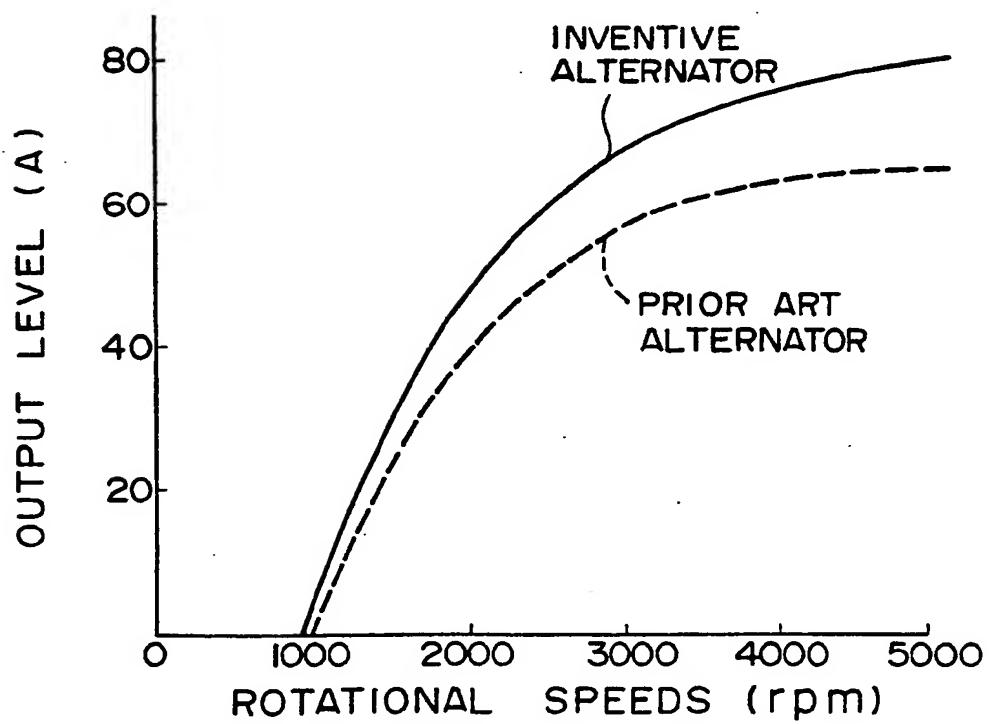


FIG. 10



STATOR FOR USE IN ALTERNATOR FOR VEHICLE
AND METHOD OF PRODUCING THE SAME

1 BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to alternators and, in particular, to a stator which is 5 suitable for use in an alternator for a vehicle or the like and which is capable of being reducted in size and of providing an increase in output, as well as to a method of producing the same.

2. Description of the Related Art

10 In such a stator for use in an alternator for a vehicle, a solid electric wire having a circular cross section as disclosed, for example, in Japanese Patent Laid-open No. 55-79660 is fitted into slots formed in the stator while retaining its cross-sectional form, 15 extensions formed along circumferentially opposing edges of the end of each toothed portion of a stator core are folded to form partially closed apertures for the slots.

As disclosed in Japanese Patent Laid-open No. 55-94567, a similar solid electric wire having a 20 circular cross section is fitted into slots formed in the stator and in turn the wire or winding is pressed in the direction of the depth of the slots in order to improve the ratio of the area occupied by the winding to that of the slot (hereinafter referred to as "space 25 factor"). Finally, opposing edges of the ends of the

1 toothed portions of the stator core are circumferential-
ly extended to form partially closed apertures for the
slots.

In the above-described related arts, however,
5 since the solid electric wire or winding having a
circular cross section is fitted into the slots without
having its cross-sectional form changed, the above space
factor cannot be improved owing to the fact that spaces
are necessarily formed between successive turns of the
10 winding. This makes it difficult to improve the level
of output of the alternator. In the type in which
pressure is applied to the solid electric wire or wind-
ing of circular cross section which has been fitted
into the slots, the turns of the winding within the
15 slots may partially cross each other, so that it might
become impossible to maintain the proper arrangement of
the turns of the winding. As a result, while the
winding is being pressed, the electrically insulating
film coated over the surface of the winding may be
20 damaged and, hence, the windings might be short-
circuited. Accordingly, adoption of such a method
results in an increased proportion of defects occurring
during a mass-production process and, hence, a lowering
in productivity.

25 It is widely known that large electric rotary
machines in particular employ a flat rectangular wire
in place of a round wire. However, if such flat
rectangular wire is used, as it is, in small alternators

1 or the like to which the present invention pertains,
the following disadvantages will result. In general,
before being fitted into the slots, the winding needs
to be formed into a predetermined shape. However, in a
5 mass-production process for producing a large volume of
windings in a short period of time by means of winding
machines, use of this type of flat rectangular wire
is not suitable, since such wire is inferior in
workability as compared with the round wire because of
10 the presence of curvature or twisting at its end coil
portions.

SUMMARY OF THE INVENTION

It is therefore an object of the present
invention to provide a structure for a stator suitable
15 for use in an alternator for a vehicle and a method of
producing such a stator in which the space factor of a
winding is greatly improved to increase the level of
output of the alternator; in which the winding coating
is in no way damaged during assembly; and which is
20 superior in productivity.

The above object is achieved by providing a
stator suitable for use in an alternator for a vehicle
comprising a stator core having a plurality of slots
formed in its inner periphery; a stator winding partial-
25 ly inserted in each of the slots of the stator core;
and an electrically insulating material inserted between
the stator winding and the surface of the stator core.

1 opposing the stator winding, wherein the slots formed
in the stator core have a substantially rectangular form
in cross section and the portions of the stator winding
to be inserted into the slots also have a substantially
5 rectangular form in cross section, with the other por-
tion having a circular cross-sectional form.

In accordance with the present invention, part
of the winding fitted into the slots of the stator is
so formed that the portions of the winding inserted
10 into the slots are provided with a substantially rectan-
gular cross-sectional shape by the application of
pressure, whereby the space factor of the winding
within the slots is greatly improved. In addition,
since the winding is made from winding material having
15 at least a circular cross-sectional form, it is possible
to eliminate various disadvantages which might have
heretofore been involved in winding formation.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross section of a portion of a
20 stator for use in an alternator for a vehicle in accord-
ance with the present invention;

Fig. 2 is a view taken in the direction
indicated by an arrow II of Fig. 1;

Figs. 3 through 5 are diagrammatic views
25 illustrating the formation of stator winding for the
stator incorporated in an alternator for a vehicle in
accordance with the present invention;

1 Fig. 3 illustrates the wound state of winding
material to which the invention pertains;

5 Fig. 4 is a diagrammatic perspective view
illustrating the process of pressing the winding
material shown in Fig. 3 by means of a pressure former;

Fig. 5 is a diagrammatic perspective view
illustrating a stator winding which is formed in accord-
ance with the present invention;

10 Fig. 6 is a diagrammatic perspective view of
a stator core of an alternator for a vehicle in accord-
ance with the present invention, and illustrates a state
wherein extensions serving as magnetic flux collecting
portions have not yet been formed;

15 Figs. 7A and 7B are schematic views illustrat-
ing a method of producing the magnetic flux collecting
portions of the stator for an alternator for a vehicle
in accordance with the present invention, with Fig. 7A
showing a state wherein a stator winding is fitted into
the slots of the stator while Fig. 7B showing a state
20 wherein the end surface of each toothed portion of the
stator core is formed under pressure;

25 Figs. 8A and 8B are cross sections of another
example of the stator winding of the stator of an
alternator for a vehicle in accordance with the present
invention, with Fig. 8A being a cross section of a
hollow conductor wire while Fig. 8B shows the hollow
conductor wire which is formed under pressure in a
substantially rectangular cross section.

1 Fig. 9 is a diagrammatic cross section of an
alternator for a vehicle which incorporates the stator
of the invention;

5 Fig. 10 is a characteristic chart illustrating
a comparison between the output characteristic of the
alternator for a vehicle which incorporates a stator of
the invention and the output characteristic of a con-
ventional type of vehicle alternators.

DESCRIPTION OF THE PREFERRED EMBODIMENT

10 A stator suitable for use in an alternator
for a vehicle in accordance with the present invention
and a method of producing the same will be described
below in conjunction with an illustrated preferred
embodiment. In the drawings, like reference numerals
15 are used to identify like or corresponding elements.

Fig. 1 illustrates in cross section a portion
of the armature of an alternator for a vehicle, that
is, a stator 1. The stator 1 has a stator core 2
composed of laminated steel plates each having a pre-
20 determined stamped form. The stator core 2 has a
cylindrical portion 3 and a plurality of toothed por-
tions 4 each of which projects radially inward of the
cylindrical portion 3, and each slot 5 is defined
between adjacent toothed portions 4. The slot 5 has
25 a rectangular cross section. In the present embodi-
ment, the stator 1 which is suitable for use in an
alternator for a vehicle has twelve slots formed in

1 the cylindrical portion 3 of the stator core 2 on the
side of its inner periphery. In Fig. 1, only three of
these slots are shown, by way of example. A pair of
5 extensions 6, which are elongated circumferentially in
opposite directions, are formed on the circumferentially
opposing edges of the inner end of each of the toothed
portions 4. Each of the extensions 6 serves to collect
magnetic flux and to define the partially closed
aperture of the slot 5 for the purpose of preventing
10 projection of a winding which will be described in
detail later.

In the present embodiment, a stator winding 7 composed of six turns is inserted in each of the slots 5 of the stator 1. As a matter of course, this stator
15 winding is wound so that three-phase output may be provided in a similar manner to that of prior art vehicle alternators. An electrically insulating sheet 8, such as "Nomex", having a high degree of heat resistance is interposed between the stator core 2 and the
20 stator winding 7. Thus electrical insulation is positively provided between the stator core 2 and the stator winding 7.

Fig. 2 is a plan view of the alternator stator 1 shown in Fig. 1, taken in the direction indicated by
25 an arrow II of Fig. 2. As clearly shown in Fig. 2, the stator winding 7 accommodated in the slot 5 of the stator core 2 has a portion 7a and coil end portions 7b. The portion 7a is inserted in the slot 5 and has a flat or

1 rectangular cross section. The remaining portions or
coil end portions 7b have a circular cross-sectional
form. As can be seen from the foregoing, since each
of the slots 5 having a substantially rectangular form
5 in cross section receives the winding which has a
similarly rectangular form in cross section, the space
factor of the winding within the stator slot 5 is
improved.

A method of producing the above-described
10 stator winding 7 will now be described.

As shown in Fig. 3, a solid electric-wire
material 17 having a circular cross section is wound
several times, e.g., six times, into a substantially
rectangular form, thereby preparing a winding having a
15 predetermined form. In the illustrated example, the
winding material 17 is wound into a substantially
rectangular form and coil end portions 17b are shaped
in an arc. Therefore, when the winding is inserted into
the slot 5 of the stator core 2, the coil end portion
20 17b is adapted to be easily worked. Also, since
electric-wire material having a circular cross sectional
form is used, no deterioration in workability occurs
due to twisting of the electric wire in contrast to the
case in which the aforesaid winding is formed from a
25 so-called rectangular wire. It is therefore unnecessary
to take account of twisting of electric wires. Accord-
ingly, it is evident that the present winding material
is suitable for use in a mass-production process because

1 of the superior workability.

After the stator winding material 17 has been shaped into a predetermined form in the above-described manner, its portion 17a thereof which is to be inserted 5 into the slot 5 is shaped in a flat form by a pressure former 9. The pressure former 9 has a base 10, a stopper 11 provided on the mid portion half way along the base 10 in the lengthwise direction, a pair of blocks 12 provided at the longitudinal opposite ends 10 of the base 10, a pair of sliders 13 longitudinally slidable over the base 10, springs 14 each secured at one end to the block 12 and at the other to the slider 13, and a pusher 15 moved vertically by means of hydraulic pressure or the like. The winding material 15 which has been formed as shown in Fig. 3 is inserted between the stopper 11 and the sliders 13, and the portions 17a thereof which are to be inserted into the slots, that is, the portions other than the coil end portions 17b are retained therebetween by the force of 20 the springs 12. Thereafter, the inserted portions 17a are pressed by the pusher 15 in the direction indicated by an arrow shown in Fig. 4. As the result of this application of pressure, the stator winding material 17 is formed into a stator winding 7 such as that shown 25 in Fig. 5 in which the portion other than the coil end portions 7b, that is, the portions 7a to be inserted into the slot 5, has a substantially square, e.g., rectangular form in cross section. In the above-

1 described embodiment, after the winding material has
been wound and the thus-obtained winding have been
placed in such a manner that its turns are superimposed,
predetermined portions of the superimposed turns are
5 pressed. However, after the predetermined portions
alone of the winding material have been pressed, the
obtained winding material may be wound into a desired
form.

The stator winding 7, which has been formed
10 in the above-described manner, is securely inserted
into each of the slots 5 defined between the adjacent
toothed portions 4 of the stator core 2 shown in Fig.
6, with an electrically insulating sheet interposed
therebetween. As shown in Fig. 6, a substantially
15 ellipsoidal through hole 16 is axially formed through
each of the toothed portions 4 of the stator core 2.
As will be described later, the previously-mentioned
extensions 6 serving as magnetic-flux collecting
portions are formed by pressing the end surface of each
20 of the toothed portions 4. It is thus possible to
prevent the inserted winding from coming out of the
slots 5. As will be evident from the foregoing, after
the winding 7 has been inserted into each of the slots
5, the extension 6 serving as a magnetic-flux collecting
25 portion is formed on the end surface of the toothed
portion 4 of the stator core 2. Accordingly, even the
winding 7 that is formed in a substantially rectangular
shape can be easily inserted into each of the slots 5.

- 1 It will be appreciated that the efficiency of assembly
is remarkably improved, particularly, in a mass-
production process.

The following is a description of a method of
5 forming the extensions that serve as magnetic-flux
collecting portions of the stator core 2.

Referring to Fig. 7A, six turns of the stator
winding 7 are inserted into each of the slots 5 with the
electrically insulating sheet 8 interposed between the
10 winding 7 and the surface of the slot 5.

Subsequently, as shown in Fig. 7B, the end
surface of the toothed portion 4 of the stator core 2
is pressed by means of a suitable pressing means (for
example, a press or a roller) in the direction indicated
15 by illustrated arrows F. As shown by solid lines in
Fig. 7B, the through holes 16 axially formed through
the end portions of the toothed portions 4 are crushed
and at the same time the portions of the stator core 2
adjacent to the circumferentially opposing sides of the
20 through hole 16 are squeezed outwardly parallel to the
circumference of the stator core 2. It is therefore
possible to form the magnetic-flux collecting portions
6 so that each has an ideal shape close to an arc.

In the above-described embodiment, by way of
25 example, the solid electric-wire material having a
circular cross-sectional form is used to form the stator
winding. In the present invention, however, a hollow
conductor wire 27 such as that shown in Fig. 8A may be

1 used in place of the circular wire material. As
illustrated, the hollow conductor core 27 originally
has an annular cross section. If the conductor core 27
is pressed, it assumes an elongated form with rounded
5 ends such as that shown in Fig. 8B. As is evident from
the foregoing, if the hollow conductor 27 is employed
in the pressing process explained previously in connec-
tion with Fig. 4, the level of pressure required for
pressing can be reduced as compared with the solid round
10 wire, and it is possible to easily and positively shape
the round wire into a rectangular cross-sectional form.
As a matter of course, the portions of the hollow
conductor 7 to be inserted into the slots are formed
in a flat shape. In addition, the degree of pressure
15 required for working the hollow conductor wire can be
reduced as compared with that required when working a
solid conductor wire. Accordingly, an electrically
insulating film coated over the winding is less likely
to be damaged during pressing, and the proportion of
20 defects can be reduced to an extremely low level.

Fig. 9 shows in cross section an alternator
for a vehicle which incorporates the above-described
stator 1. Fig. 10 illustrates a comparison between the
output characteristic of a typical prior art alternator
25 and that of an alternator which incorporates the stator
of the present invention. As can be seen from Fig. 10,
with the arrangement of the present invention, it is
possible to improve the ratio of the area occupied by

1 the winding to that of the slot, that is, the space
factor to a level equivalent to about 80%. In conse-
quence, as shown in the characteristic chart of Fig. 10,
it is possible to enhance the level of output over the
5 range of all rotational speeds of the alternator as
compared with the output level of the prior art vehicle
alternator having the same size (its output character-
istic is shown by a dashed line). In particular, it
was confirmed that the level of output at a rated
10 rotational speed of 5000 rpm could be increased by about
25% as shown by a solid line.

As is evident from the foregoing description,
the present invention succeeds in providing a stator
having a large space factor suitable for use in an
15 alternator for a vehicle so that it is possible to
achieve a vehicle alternator which is capable of being
reduced in size and of providing an increase in output.

CLAIMS:

1. A stator suitable for use in an alternator for a vehicle comprising:

a stator core having a plurality of slots formed in an inner periphery thereof;

5 a stator winding having portions inserted in each of said slots of said stator core; and an electrically insulating material inserted between said stator winding and said stator core;

wherein said slots formed in said stator 10 core have a substantially rectangular cross-sectional form, and said portions of said stator winding inserted into said slots also have a rectangular cross-sectional form and a remainder of said stator winding has a circular cross-sectional form.

15 2. A stator according to Claim 1, wherein said remainder of said stator winding has a hollow cross-sectional form.

3. A method of producing a stator suitable for use in an alternator for a vehicle, said stator including 20 a stator core having a plurality of slots formed in an inner periphery thereof, a stator winding having portions inserted in each of said slots of said stator core, and an electrically insulating material inserted between said stator winding and said stator core, comprising 25 the steps of press-forming the portions of said stator winding to be inserted into each said slot from its circular cross-sectional form into a substantially

rectangular cross-sectional form.

4. A method according to Claim 3, wherein said stator winding is produced from a winding material having a hollow cross-sectional form.

5 5. A method of producing a stator suitable for use in an alternator for a vehicle, said stator including a stator core having a plurality of slots formed in an inner periphery thereof, a stator winding having portions inserted in each of said slots of said stator 10 core, and an electrically insulating material inserted between said stator winding and said stator core, comprising the steps of winding a winding material having a circular cross-sectional form into a predetermined winding shape; and subsequently press-forming the 15 portions of said stator winding to be insettled into each said slot from its circular cross-sectional form into a substantially rectangular cross-sectional form.

6. A method according to Claim 5, wherein said stator winding is produced from a winding material 20 having a hollow cross-sectional form.

7. A method of producing a stator suitable for use in an alternator for a vehicle, said stator including a stator core having a plurality of slots formed in an inner periphery thereof, a stator winding having 25 portions inserted in each of said slots of said stator core, and an electrically insulating material inserted between said stator winding and said stator core, comprising the steps of press-forming the portions of

said stator winding to be insetted into each said slot from its circular cross-sectional form into a substantially rectangular cross-sectional form; and subsequently winding said winding material into a predetermined winding form, thereby forming said stator winding.

8. A method according to Claim 7, wherein said stator winding is produced from a winding material having a hollow cross-sectional form.

9. A stator substantially as herein described
10 with reference to and as shown in Figures 1 to 7B, 9
and 10 or 8A or 8B of the accompanying drawings.

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